Study of χ_c production in pPb collisions at $\sqrt{s_{NN}}$= 8.16 TeV energy with the CMS experiment

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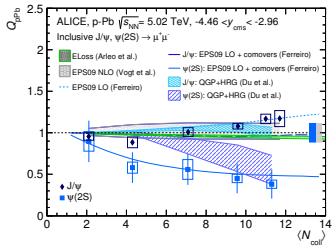
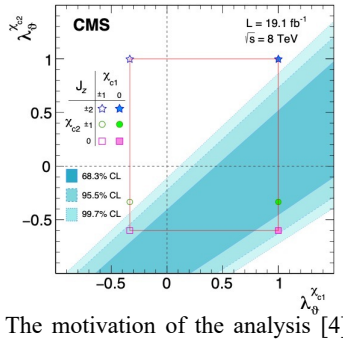
Introduction

Proton-lead (pPb) collisions at the LHC provide an opportunity to study nuclear modification effects on quarkonia.

Excited S-wave state $\psi(2s)$ shows different suppression than the ground state J/ψ by the ALICE experiment. A trend of increasing relative suppression of $\psi(2s)$ to J/ψ is observed as multiplicity or related variables increases [1].



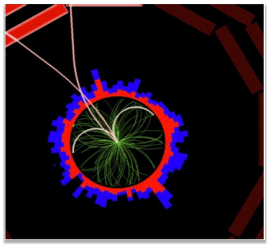
P-wave state charmonia $\chi_c$were studied in proton-proton collisions with 7 and 8TeV energies in the CMS experiment [2,3]. The results of polar anisotropy coefficients $\lambda_\vartheta^{\chi_{c1}}$, $\lambda_\vartheta^{\chi_{c2}}$ indicates that both χ_{c1} and χ_{c2} are strongly polarized [3].



The motivation of the analysis [4] is to study how χ_c are affected in pPb compared to pp collisions based on data collected by CMS at the LHC with an integrated luminosity of $175nb^{-1}$. It is also the step toward the χ_c measurements in PbPb collisions.

Signal yield extraction

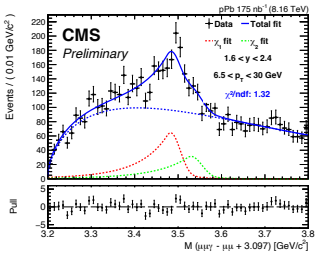
The χ_c candidates are reconstructed through the radiative $\chi_c \rightarrow J/\psi\gamma$ decays. The J/ψ is reconstructed through its decay to a muon pair, while the photon is reconstructed through its conversion to an e^-e^+ pair detected in the silicon tracker.



The χ_c mass is calculated using the world average of experimentally values of the J/ψ mass instead of the invariant mass of the di-muon :

$$m_{\chi_c} = m_{\mu\mu\gamma} - m_{\mu\mu} + 3.097GeV,$$

which improves χ_c mass resolution by removing the di-muon resolution.

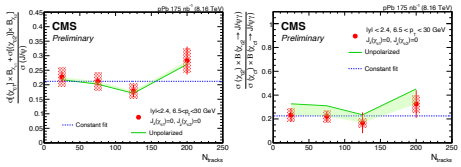


The yields of χ_{c1} χ_{c2} are extracted from fitting the m_{χ_c}spectrum. The non-prompt χ_c contamination is evaluated and taken into account as a source of uncertainty.

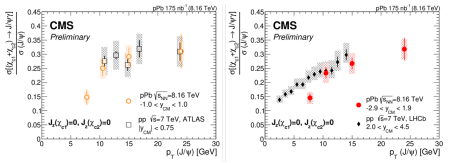
Source of uncertainty		Uncertainty [%] χ_c-to-J/ψ ratio	χ_{c2}-to-χ_{c1} ratio
χ_c fit shape		0.03–4	1–4
J/ψ fit shape	signal	0.3–2	—
	background	0.05–0.3	—
Conversion selection		12	23
Conversion selection - tag and probe		5	5
PYTHIA settings		6–12	0.1–0.5
Nonprompt contamination		5	8
Total systematic uncertainty		13–17	16–17

Results and conclusions

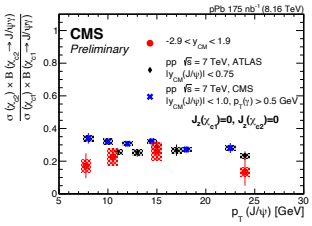
Results of the measurements are interpreted as the χ_c-to-J/ψ and χ_{c2}-to-χ_{c1} cross section ratios. Both χ_{c2} and χ_{c1} are assumed to be fully polarized with $J_z(\chi_{c2}) = J_z(\chi_{c1}) = 0$.



❑ χ_c-to-J/ψ (left panel) and χ_{c2}-to-χ_{c1} (right panel) ratio as a function of number of tracks in the event.



❑ χ_c-to-J/ψ ratio as a function of $p_T(J/\psi)$ comparing to pp in a similar kinematic range and collision energy from ATLAS(left panel) and LHCb (right panel) results.



❑ χ_{c2}-to-χ_{c1} ratio as a function of $p_T(J/\psi)$. No p_T trend and results are found to be similar to pp measurements from ATLAS [5] and CMS [2].

As a summary, no additional modification of χ_c compared to J/ψ is observed in pPb collisions. In contrast to $\psi(2s)$[6], the lack of dependence of the χ_c-to-J/ψ ratio on event multiplicity suggests weaker modification effects for χ_c in pPb collision.

Reference :
[1] The ALICE Collaboration, JHEP 06 (2016) 050
[2] The CMS Collaboration, EPJC 72 (2012) 225
[3] The CMS Collaboration, PRL 124 (2020) 162002
[4] The CMS Collaboration, CMS-PAS HIN-22-003
[5] The ATLAS Collaboration, JHEP 07 (2014) 154
[6] The CMS Collaboration, PRL 135 (2025) 092301